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A FAST COINCIDENCE CIRCUIT WITH PULSE HEIGHT SELECTION *

By P. R. Bell, S. DeBenedetti, and J. E. Francis, Jr.

ABSTRACT

The output signal of a linear amplifier may have a rise time of $1-2 \times 10^{-7}$ seconds. Therefore, the output of a pulse height selector operating on this signal has a variation of delay from the original signal of about this amount. Since this delay depends on the pulse height, the pulse height selector output is unsuitable for fast coincidence work. In the instrument to be described this difficulty is largely removed by feeding the amplifier signal into two separate channels: the first in a pulse height selector which produces a rectangular pulse (gate) longer than the amplifier signal when this signal height falls between two adjustable limits of voltage; the second channel limits, differentiates and delays the amplifier signal so that it falls within the "gate" duration. The pulses from the two channels are fed to a coincidence circuit whose output reproduces the constantly delayed and sharpened amplifier pulse only when the gate pulse is present. This scheme has been employed to obtain simultaneous or delayed coincidences between pulses (with a height falling between two specified limits) from one chamber, and pulses greater than a known height from a second counter. The resolving time is approximately .4 microseconds.

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When coincidence counting is to be done with signals whose amplitude varies from pulse to pulse some difficulties are found that are not found when dealing with signals of uniform size. Signals of varying amplitude might arise from ionization chambers or proportional counters and it is generally desired to select from coincidence purposes only those signals whose amplitude lies above a selected value or those whose amplitude lies between two selected values.

The output signal or "gate" from a circuit pulse height selector that selects those pulses greater than some set amplitude cannot begin until the signal voltage has reached this triggering level. As a consequence the gate will begin at various times after the signal starts from almost no delay at all for a very large pulse to a delay equal to the time required for the signal to rise to the very crest for a signal that barely triggers the pulse height selector.

If the output of the pulse height selector is used for coincidence work the resolving time cannot be less than the rise time of the signal plus the length of time required for the operation of the coincidence circuit.

One method for reducing the effect of this variable delay is to use the output of the pulse height selector only to select the desired pulses between which coincidence is to be determined and perform the coincidences between the original signals after they have been suitably limited and delayed. Figure 1 shows one arrangement. Here the signals from counter or chamber 1 are amplified and fed into a pulse height selector and into delay line No. 1. The output of the delay line is sharply limited so that a signal not much above the level of the background noise produces full

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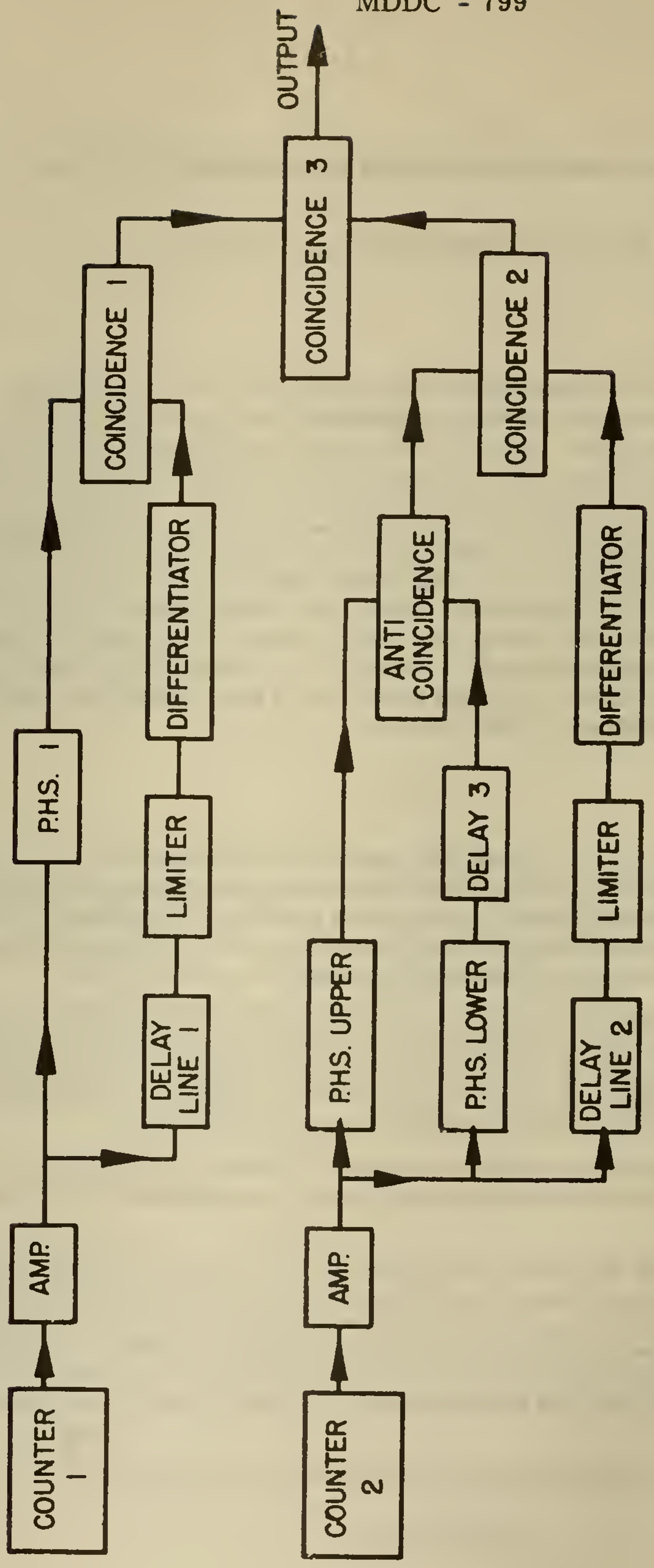
COUNTER 1
AMP.
P.H.S. 1
DELAY LINE 1
LIMITER
DIFFERENTIATOR
COINCIDENCE 1
COINCIDENCE 3
OUTPUT
COUNTER 2
AMP.
P.H.S. UPPER
P.H.S. LOWER
DELAY 3
ANTI COINCIDENCE
DELAY LINE 2
LIMITER
DIFFERENTIATOR
COINCIDENCE 2

Figure 1.

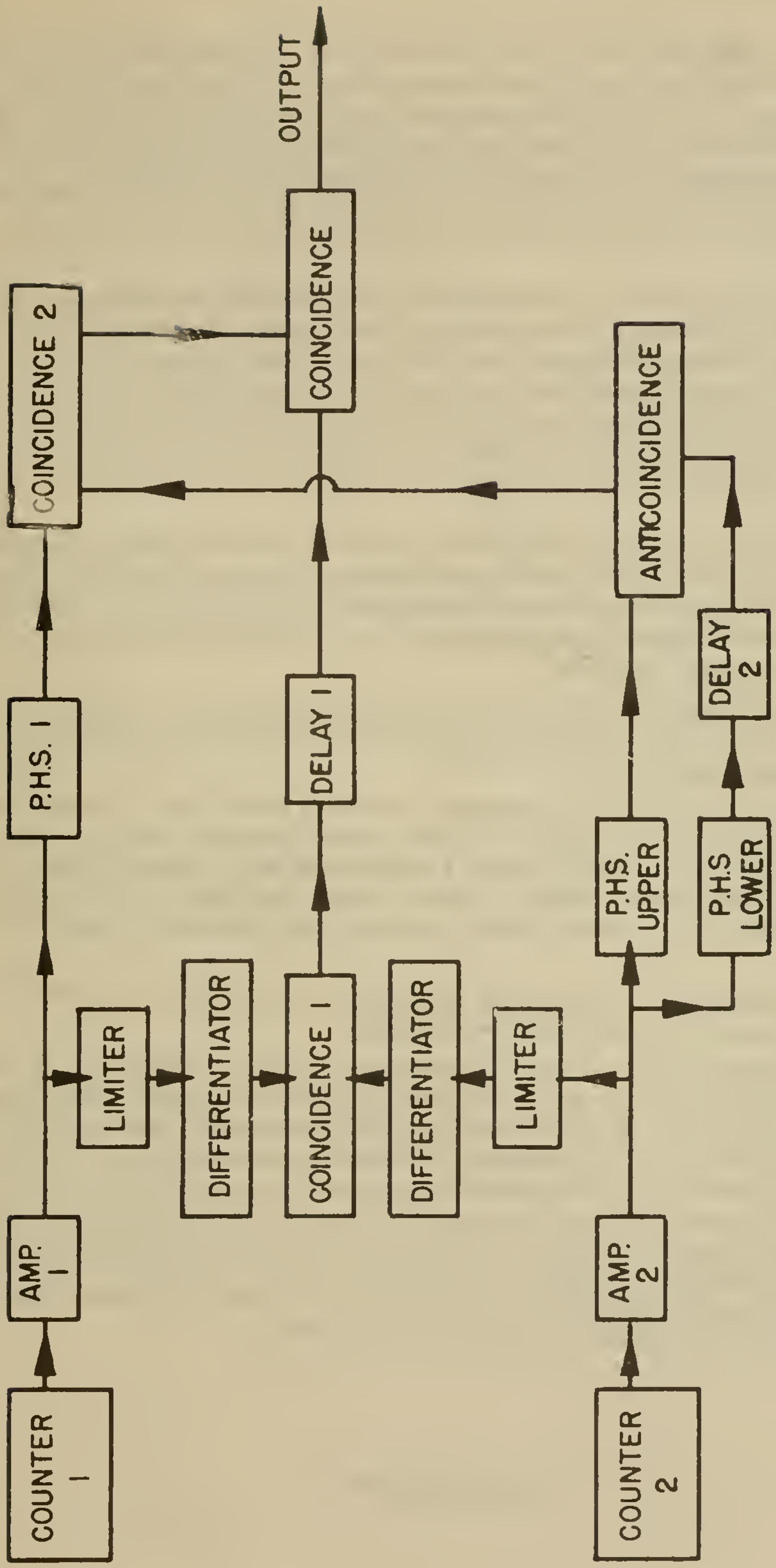
COUNTER 1
AMP. 1
P.H.S. 1
COINCIDENCE 2
LIMITER
DIFFERENTIATOR
COINCIDENCE 1
DELAY 1
COINCIDENCE
OUTPUT
DIFFERENTIATOR
LIMITER
COUNTER 2
AMP. 2
P.H.S. UPPER
P.H.S LOWER
DELAY 2
ANTICOINCIDENCE

Figure 2.

output. This limited signal is differentiated by an RC circuit and the resulting pulse fed to a coincidence circuit together with the gate from the pulse height selector. The gate from the pulse height selector is made equal to or slightly larger than the length of the differentiated pulse plus the maximum variation in delay due to the variation in signal height. The delay line delay is long enough so that the differentiated pulse will always fall inside the gate time. The output of the coincidence circuit will then be a sharp pulse with a substantially fixed delay from the beginning of the signal and this pulse will be present only when the signal was high enough to trigger the pulse height selector.

The signal from counter or chamber 2 is amplified and fed to two pulse height selectors. The two pulse height selectors are adjusted to define a region of pulse height. The lower limit pulse height selector will trigger soonest and its gate must be delayed so that if the upper pulse height selector is triggered the resulting slightly longer gate pulse will overlap the first. These two gates are fed to an anti-coincidence circuit so that a pulse will come out of this anti-coincidence circuit when the lower pulse height selector is triggered but no pulse (or an opposite sign pulse) will come out if both pulse height selectors are triggered. This is the usual differential pulse height selector.

The signal from amplifier 2 is also fed into a delay line and the delayed signal is limited and differentiated as was the case with signal 1 and the resulting pulse is fed into coincidence circuit No. 2 with the anti-coincidence gate. The output of coincidence circuit No. 2 is then a sharpened pulse with a fixed delay from its signal and is present only when the signal lies between the levels of the upper and lower pulse height selectors.

The output pulses from coincidence circuit No. 1 and coincidence circuit No. 2 can be fed into coincidence circuit No. 3 and if delay lines No. 1 and No. 2 have the same delay the pulses will be in coincidence if the original signals were.

An auxiliary delay line D_4 may be inserted between coincidence circuit No. 1 or coincidence circuit No. 2 and the third coincidence circuit to allow the random coincidence rate to be determined. An alternate method is to make delay line No. 1 shorter than delay line No. 2 thus allowing the gate pulse from coincidence circuit No. 1 to be shorter. The difference in delays in channel 1 and 2 is then made up by an auxiliary delay line which can be removed to measure the random coincidences.

By means of an instrument of this pattern using amplifiers of about 0.2 μ sec rise time an overall resolving time of about 0.2 to 0.25 μ secs was obtained.

Figure 2 shows the block diagram of another arrangement that differs from the first in that the two signals are sharpened and fed into a fast coincidence circuit at once and the desired pulses are sorted from all those obtained by the operation of the various pulse height selectors. The advantage of this circuit is that only a few operations are performed on the signals until coincidence is obtained. After this no damage can be done to the resolving time by the delay lines and other coincidence circuits in the system. In this arrangement the output gate from pulse height selector No. 1 is put into coincidence circuit No. 2 with the anti-coincidence gate from channel No. 2; coincidence is then sought by circuit No. 3 between the gate from coincidence circuit No. 2 and the output pulse from the signal coincidence circuit No. 1. It is necessary to delay this pulse to allow it to fall into the time occupied by the gate from coincidence circuit No. 2.

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